Species Report of *Stenogyne angustifolia* var. *angustifolia* (no common name)

Version 1.0

Stenogyne angustifolia var. *angustifolia* plant with flower. Photo Credit: Chris Wong

January 2021
Pacific Islands Fish and Wildlife Office
U.S. Fish and Wildlife Service
Honolulu, HI

This document was prepared by the staff at the Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i. We received valuable input and assistance from the following experts: Edith Adkins and Elliott Parsons from the State of Hawai‘i Department of Land and Natural Resources Division of Fish and Wildlife (DLNR-DOFAW). We greatly appreciate their guidance and support, which resulted in a more robust report.

Suggested reference:
U.S. Fish and Wildlife Service (USFWS). 2021. Species report for *Stenogyne angustifolia* var. *angustifolia*. Pacific Islands Fish and Wildlife Office, Pacific Islands Interior Region 12, Portland OR. 35 pages.

EXECUTIVE SUMMARY

This Species Report for *Stenogyne angustifolia* var. *angustifolia* was completed to assess the species' overall viability. To assess viability we used the three conservation biology principles of resiliency, representation, and redundancy. We identified the species' ecological requirements for survival and reproduction at the individual, population, and species levels, and described risk factors influencing the species' current condition.

Stenogyne angustifolia var. *angustifolia* is a short-lived, low-growing perennial vine in the mint family (Lamiaceae) endemic to the islands of Molokaʻi, Maui, and Hawaiʻi. Originally collected from the Waimea District on Hawaiʻi Island in 1840, the species was described by Asa Gray in 1862 (USFWS 1993, p. 3; USFWS 2012, p. 9). Subsequently, Sherff (1935) recognized six island-endemic varieties: var. *hillebrandii* (Molokaʻi), var. *mauiensis* (Maui), and vars. *meeboldii*, *salicifolia*, and *spathulata* (Hawaiʻi), in addition to var. *angustifolia* on Hawaiʻi Island. Only *S. angustifolia* var. *angustifolia* was included in the final rule determining endangered status in 1979 (USFWS 1979, p. 62,468; Wagner et al. 1999, p. 835). Wagner et al. (1999, p. 835) subsequently grouped all the variants as synonyms, but the federally listed name has not yet been updated to reflect this revision of *S. angustifolia*, which now comprises records from three islands.

Stenogyne angustifolia var. *angustifolia* formerly occurred in dry subalpine shrublands, a subtype of dry shrubland habitat, 5,085 to 7,053 feet (ft) (1,550 to 2,150 meter [m]) on islands of Molokaʻi, Maui, and Hawaiʻi. Dry subalpine shrublands occur on sandy-loamy soils derived from volcanic ash or sand, or weathered lava and have a seasonal climate with drought conditions during the summer months of May to October; rainfall mostly occurs in the winter months of November to March. This habitat experiences extremely dry and cold climate, with frequent frost that occurs even in summer months (Peʻa et al 2020, pp. 2–3). Presently, this species is restricted to the Pōhakuloa Training Area (PTA) and Puʻu Anahulu Game Management Area on Hawaiʻi and occupy mesic and dry forest and shrubland habitats (Wagner et al. 1999, p. 835; USFWS 2012, p. 8).

The immediate and potential threats facing *Stenogyne angustifolia* var. *angustifolia* include the destruction and adverse modification of habitat by feral ungulates, habitat modification and competition with non-native plants, herbivory by feral ungulates, military activities, fire (USFWS 1979, p. 62,468; USFWS 2012, p. 12), hybridization, climate change, and drought (USFWS 2012, p. 12; USFWS 2020a, p. 13).

We define resiliency as a population that will show enough reproduction to maintain or increase the numbers of individuals in the population giving the population the ability to withstand stochastic disturbance events. We can measure resiliency for *Stenogyne angustifolia* var. *angustifolia* based on the metric of population size and structure. Redundancy is having more than one resilient population distributed across the landscape increasing the ability of a species to withstand catastrophic events. We evaluated redundancy for *S. angustifolia* var. *angustifolia* based on the metrics of the number of populations, resilience of populations, and the distribution of the species across its range. Representation is defined as ecological diversity secured

throughout multiple populations across the range of the species. We can measure representation based on the habitat variation within and among populations.

This Species Report was conducted under the currently accepted taxonomy, and any differences between the viability of the currently recognized and listed entity are identified. The current condition of *Stenogyne angustifolia* var. *angustifolia* is described as having an overall minimum number of individuals of 2,517 and estimate of 3,238 wild individuals in three populations at PTA and approximately 92 wild individuals in three populations managed by State of Hawai‘i Department of Land and Natural Resources-Division of Fish and Wildlife’s (DLNR-DOFAW) Nāpu‘u Conservation Project staff, with one population within the Nā‘ōhule‘elua - Kīpuka Kalawamauna population, also on PTA for a total of five populations. Some representation is maintained in *ex situ* seed storage and translocated individuals produced from vegetative propagation and seeds to PTA, lands managed by DLNR-DOFAW, and Hawai‘i Volcanoes National Park. *Stenogyne angustifolia* var. *angustifolia* was known to inhabit dry forest, dry shrubland, mesic forest, and mesic shrubland, but currently occupy dry forest and shrubland habitats within a single narrow, geographic area of Pōhakuloa Plateau. This species has low resiliency, low to moderate redundancy, and low representation in its current condition thus, the overall viability of this species is low.

TABLE OF CONTENTS

List of Tables

List of Figures

INTRODUCTION

Stenogyne angustifolia var. *angustifolia* is a short-lived, low growing perennial vine in the mint family endemic to Molokaʻi, Maui, and Hawaiʻi Island. Six island-endemic varieties were recognized by Sherff but only *S. angustifolia* var. *angustifolia* was included in the final rule determining endangered status in 1979 (USFWS 1979, p. 62,468; Wagner et al. 1999, p. 835). Currently, this species is restricted to the Pōhakuloa Training Area (PTA) and Puʻu Anahulu Game Management Area on Hawaiʻi (Wagner et al. 1999, p. 835; USFWS 2012, p. 8).

Hawaiian Islands Dry Forest habitat status assessment (which includes lowland dry forest and montane-subalpine dry forest) (Javar-Salas et al. 2020, entire), the Hawaiʻi Dry Grasslands and Shrubland habitat status assessment (which includes dry cliff, lowland dry grassland, lowland dry shrubland, montane-subalpine dry grassland, montane-subalpine dry shrubland, and alpine dry shrubland) (Peʻa et al. 2020, entire), the Hawaiʻi: Mesic Forests habitat status assessment (which includes lowland mesic forest and montane-subalpine mesic forest) (Lowe et al. 2020, entire), and the Hawaiʻi: Mesic Grasslands and Shrublands habitat status assessment (which includes lowland mesic shrubland, lowland mesic grassland, montane-subalpine mesic grassland, and subalpine mesic shrubland) (Ball et al. 2020, entire) should be referred to for further description and discussion on dry forest, dry shrubland, mesic forest, and mesic shrubland and the threats to these habitats on Molokaʻi, Maui, and Hawaiʻi.

Species Report Overview

This Species Report summarizes the biology and current status of *Stenogyne angustifolia* var. *angustifolia* and was conducted by Pacific Islands Fish and Wildlife Office. It is a biological report that provides an in-depth review of the species' biology, factors influencing viability (threats and conservation actions), and an evaluation of its current status and viability.

The intent is for the Species Report to be easily updated as new information becomes available, and to support the functions of the Service's Endangered Species Program. As such, the Species Report will be a living document and biological foundation for other documents such as recovery plans, status in biological opinions, and 5-year reviews.

Regulatory History

Stenogyne angustifolia var. *angustifolia* was listed as endangered under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.), as amended (ESA) on October 30, 1979 (USFWS 1979 (44 FR 62,468–62,469)). A Draft Recovery Plan for *Haplostachys haplostachya* and *S. angustifolia* was completed on September 20, 1993, and a 5-year review was published on August 28, 2012. The recovery outline for the Hawaiian multi-island species was completed in 2020 which includes *S. angustifolia*. All federal regulatory information can be found at the following link: https://ecos.fws.gov/ecp0/profile/speciesProfile?sId=1591.

Methodology

We used the best scientific and commercial data available to us, including peer-reviewed literature, grey literature (government and academic reports), and expert elicitation. Due to changes in taxonomy since the time of listing, the Species Report was conducted under the currently accepted taxonomy, which expands the historic, but not the current, range of the

species. Any differences between the viability of the currently recognized and listed entity are highlighted below.

To assess the current status and viability of *Stenogyne angustifolia* var. *angustifolia*, we identified population units. The classic definition of a population is a self-reproducing group of conspecific individuals that occupies a defined area over a span of evolutionary time, an assemblage of genes (the gene pool) of its own, and has its own ecological niche. However, due to information gaps, we could not assess the viability of *S. angustifolia* var. *angustifolia* using this definition. The Hawai‘i and Pacific Plants Recovery Coordinating Committee (HPPRCC) revised its recovery objectives guidelines in 2011 and included a working definition of a population for plants: “a group of conspecific individuals that are in close spatial proximity to each other (i.e., less than 1,000 meters apart), and are presumed to be genetically similar and capable of sexual (recombinant) reproduction” (HPPRCC 2011, p. 1).

Based on this working definition, maps were created to display population units. In an effort to protect the sensitivity of species data, we created maps with symbol markers rather than displaying species points or polygons. We created the symbols in steps. First, we added a 500-meter buffer around each individual species point and polygon. We then dissolved all buffer areas intersecting each other into a single shape. Next, we created a centroid (i.e., point representing the center of a polygon) within each dissolved buffer area. The symbol marker represents the centroid. Finally, the Disperse Marker tool in ArcGIS Pro was used shift symbol markers that were overlapping so they would all be visible at the scale of the map. All points and polygons were used in this process, regardless of observation date or current status (historical, current, extant, or extirpated), to represent the known range of the species.

Species Viability

The Species Report assesses the ability of *Stenogyne angustifolia* var. *angustifolia* to maintain viability over time. Viability is the ability or likelihood of the species to maintain populations over time, i.e., likelihood of avoiding extinction. To assess the viability of *S. angustifolia* var. *angustifolia*, we used the three conservation biology principles of resiliency, redundancy, and representation, or the “3Rs” (Figure 1; USFWS 2016, entire). We will evaluate the viability of a species by describing what the species needs to be resilient, redundant, and represented, and compare that to the status of the species based on the most recent information available to us.

Definitions

Resiliency is the capacity of a population or a species to withstand the more extreme limits of normal year-to-year variation in environmental conditions such as temperature and rainfall extremes, and unpredictable but seasonally frequent perturbations such as fire, flooding, and storms (i.e., environmental stochasticity). Quantitative information on the resiliency of a population or species is often unavailable. However, in the most general sense, a population or species that can be found within a known area over an extended period of time (e.g., seasons or years) is likely to be resilient to current environmental stochasticity. If quantitative information is available, a resilient population or species will show enough reproduction and recruitment to maintain or increase the numbers of individuals in the population or species, and possibly expand the range of occupancy. Thus, resiliency is positively related to population size and growth rate, and may also influence the connectivity among populations.

Redundancy is having more than one resilient population distributed across the landscape, thereby minimizing the risk of extinction of the species. To be effective at achieving redundancy, the distribution of redundant populations across the geographic range should exceed the area of impact of a catastrophic event that would otherwise overwhelm the resilient capacity of the populations of a species. In the report, catastrophic events are distinguished from environmental stochasticity in that they are relatively unpredictable and infrequent events that exceed the more extreme limits of normal year-to-year variation in environmental conditions (i.e., environmental stochasticity), and thus expose populations or species to an elevated extinction risk within the area of impact of the catastrophic event. Redundancy is conferred upon a species when the geographic range of the species exceeds the area of impact of any anticipated catastrophic event. In general, a wider range of habitat types, a greater geographic distribution, and connectivity across the geographic range will increase the redundancy of a species and its ability to survive a catastrophic event.

Representation is having more than one population of a species occupying the full range of habitat types used by the species. Alternatively, representation can be viewed as maintaining the breadth of genetic diversity within and among populations, in order to allow the species to adapt to changing environmental conditions over time. The diversity of habitat types, or the breadth of the genetic diversity of a species, is strongly influenced by the current and historic biogeographical range of the species. Conserving this range should take into account historic latitudinal and longitudinal ranges, elevation gradients, climatic gradients, soil types, habitat types, seasonal condition, etc. Connectivity among populations and habitats is also an important consideration in evaluating representation.

The viability of a species is derived from the combined effects of the 3Rs. A species is considered viable when there are a sufficient number of self-sustaining populations (resiliency) distributed over a large enough area across the range of the species (redundancy) and occupying a range of habitats to maintain environmental and genetic diversity (representation) to allow the species to persist indefinitely when faced with annual environmental stochasticity and infrequent catastrophic events. Common ecological features are part of each of the 3Rs. This is especially true of connectivity among habitats across the range of the species. Connectivity sustains dispersal of individuals, which in turn greatly affects genetic diversity within and among populations. Connectivity also sustains access to the full range of habitats normally used by the species, and is essential for re-establishing occupancy of habitats following severe environmental stochasticity or catastrophic events (see Figure 1 for more examples of overlap among the 3Rs). Another way the three principles are inter-related is through the foundation of population resiliency. Resiliency is assessed at the population level, while redundancy and representation are assessed at the species level. Resilient populations are the necessary foundation needed to attain sustained or increasing representation and redundancy within the species. For example, a species cannot have high redundancy if the populations have low resiliency. The assessment of viability is not binary, in which a species is either viable or not, but rather on a continual scale of degrees of viability, from low to high. The health, number and distribution of populations were analyzed to determine the 3Rs and viability. In broad terms, the more resilient, represented, and redundant a species is, the more viable the species is. The current understanding of factors, including threats and conservation actions, will influence how the 3Rs and viability are interpreted for *Stenogyne angustifolia* var. *angustifolia*.

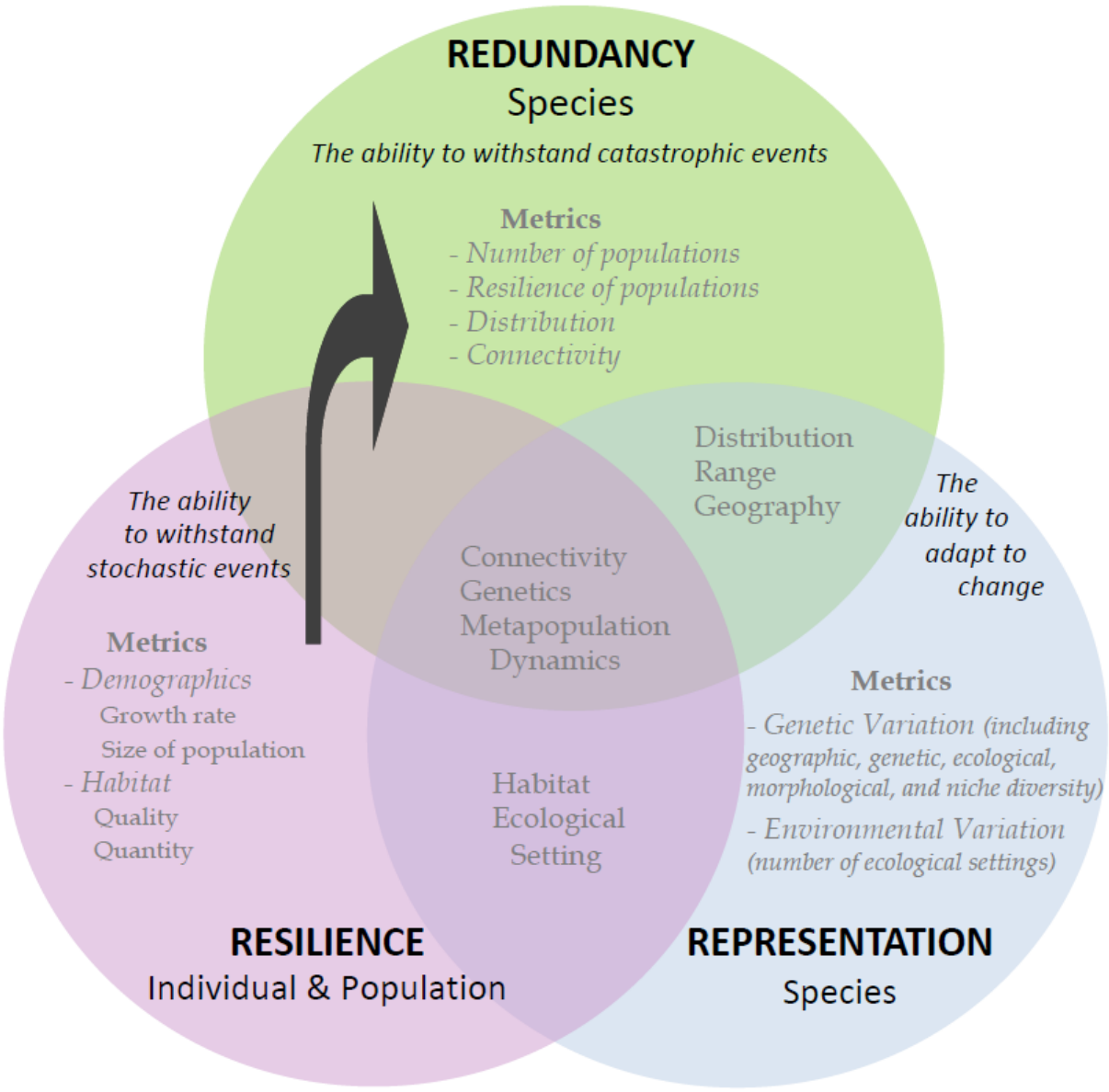

Figure 1. The three conservation biology principles of resiliency, redundancy, and representation, or the "3Rs".

SPECIES ECOLOGY

Species Description

Stenogyne angustifolia var. *angustifolia* is a short-lived, low-growing perennial vine in the mint family (Lamiaceae) endemic to islands of Molokaʻi, Maui, and Hawaiʻi (Figure 2). Stems are usually hairless and are square or round. Leaves are simple and hairless, and are 1 to 2 inches (in) (2.5 to 5 centimeters [cm]) long, 0.2 to 0.6 in (0.5 to 1.5 cm) wide, and may be wider and pointed at one end (i.e., arrow-head shaped). Teeth on the leaf margin are minute and forward-pointed. Flowers vary in color from dull yellow to magenta; they are externally hairy and occur

in pairs at nodes (USFWS 1993, p. 4). Flowers at the Puʻu Anahulu Māuka 1 population (G) were of a brown-purple color (HBMP 2010) while flowers were of a yellow to dull brown-pink color at the Waikōloa population (M) (U.S. Exploration Expedition 1859). No pattern in the variation of corolla color among populations was noted. The fruit is purple-black, nearly spherical, and fleshy; a hardened inner-layer contains the seed (USFWS 1993, p. 4).

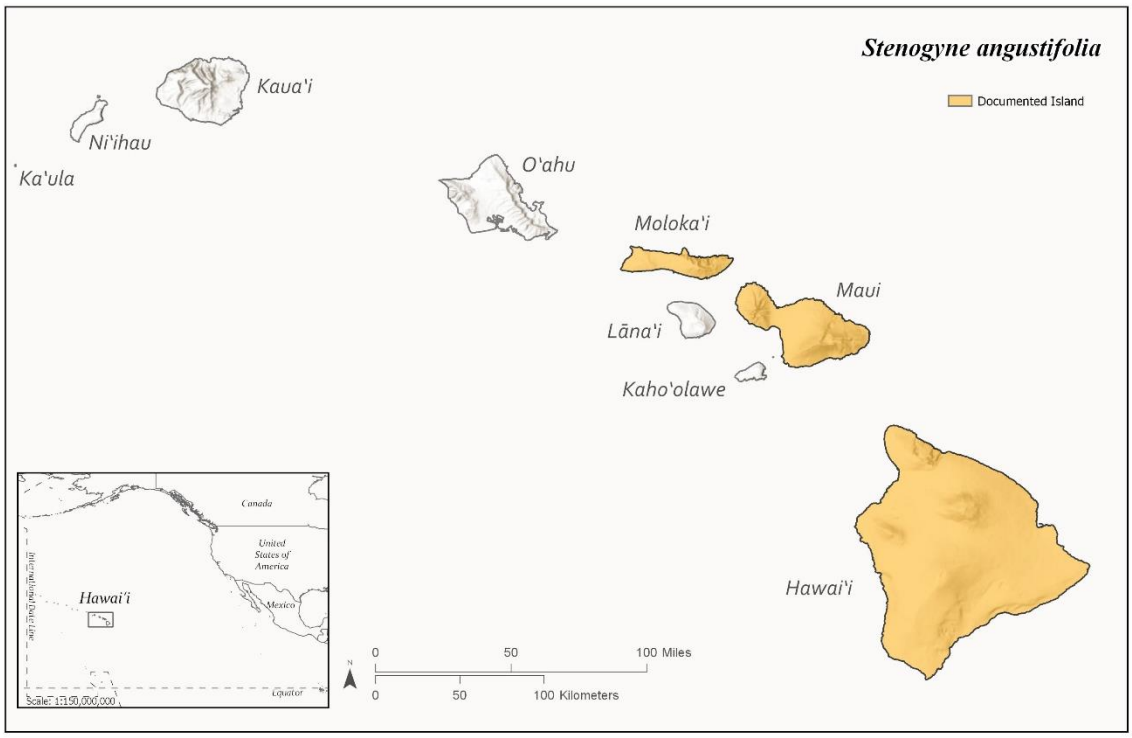

Figure 2. Map of the Hawaiian Islands showing which islands *Stenogyne angustifolia* var. *angustifolia* historically and current occupy.

Using phylogenetic analyses of DNA sequence data, Lindqvist and Albert (2002, p. 1710; USFWS 2012, p. 9) evaluated the hypothesized origin of the three endemic genera of Hawaiian mints (*Haplostachys*, *Phyllostegia*, *Stenogyne*) from its supposedly closely related East Asian relatives. Surprisingly, Lindqvist and Albert discovered that the mints from Hawai‘i were most closely related to a group of temperate North American *Stachys* from the Pacific coast, suggesting that they were derived from a single colonization event from western North America to the Hawaiian Islands. Furthermore, the Hawai‘i genera were found to be monophyletic but deeply nested inside the genus *Stachys*, and Lindqvist and Albert (2002, p. 1,720) suggested that it would be biologically logical to transfer *Haplostachys*, *Phyllostegia*, and *Stenogyne* into the genus *Stachys*, in the strict sense defined in their paper. They point out that it would be a nomenclatural daunting task, as 26 of the 60 specific epithets of recognized mints from Hawai‘i already exist in *Stachys* and new epithets would have to be provided for them. A potential alternative would be to retain the three genera of mints from Hawai‘i (whose common ancestor was of hybrid origin), but to describe new genera for other recognized lineages of hybrid origin within *Stachys* (i.e., new genera for *Stachys chamissonis* (hedge-nettle) and *S. quercetorum* (hedge-nettle), three genera for the Hawaiian mints, and one or more genera for the MEX clades,

which are paraphyletic in the total evidence result and taxonomically interspersed in the *rbcL* 1 *trnL* haplotypic tree) (Lindqvist and Albert 2002, pp. 1,720–1,721). As of 2016, no nomenclatural changes had been published (Welch 2016a and 2016b, p.1).

The genus *Stenogyne* is endemic to the Hawaiian Islands with 22 species and two subspecies recognized (Wagner and Weller 1999, p. 448; Wood and Oppenheimer 2008, p. 545). The younger islands of Maui and Hawai‘i contain the highest diversity of species in this genus with 11 and 9 species, respectively (Wagner and Weller 1999, p. 448; Wood and Oppenheimer 2008, p. 545), while the older islands contain lesser diversity; Moloka‘i (3 species), Lāna‘i (1 species), O‘ahu (3 species), and Kaua‘i, (3 species) (Wagner and Weller 1999, p. 448; Wood and Oppenheimer 2008, p. 545). *Stenogyne angustifolia* var. *angustifolia* was originally collected from the Waimea District on Hawai‘i Island in 1840. The species was described by Asa Gray in 1862 (USFWS 1993, p. 3; USFWS 2012, p. 9). Subsequently, Sherff (1935) recognized six island-endemic varieties: var. *hillebrandii* (Moloka‘i), var. *mauiensis* (Maui), and vars. *meeboldii*, *salicifolia*, and *spathulata* (Hawai‘i), in addition to var. *angustifolia* on Hawai‘i Island. Only *S. angustifolia* var. *angustifolia* was included in the final rule determining endangered status in 1979 (USFWS 1979, p. 62,468; Wagner et al. 1999, p. 835). Wagner et al. (1999, p. 835) subsequently grouped all the variants as synonyms, but the federally listed name has not yet been updated to reflect this revision of *S. angustifolia*, which now comprises records from three islands.

Little is known about the life history of *Stenogyne angustifolia* var. *angustifolia*. Plants have been observed flowering most months of the year (USFWS 1993, p. 17; USFWS 2012, p. 6). Flowers are bisexual (each flower contains both functional female and male reproductive structures) (USFWS 1993, p. 17). The lack of odor, flower shape (a smaller lower lip and longer-tubed), color (ranging between red, pink, and yellow), stamen position, and high-levels of nectar suggest that *S. angustifolia* var. *angustifolia* is probably pollinated by native honeycreeper birds (Weller and Sakai, 1990, pp. 831–843; USFWS 1993, p. 17; Lindqvist and Albert 2002, p. 1,710). In addition, numerous insects have been observed crawling upon the stems, leaves, and flowers and may also serve as pollination vectors (USFWS 1993, p. 17). *Stenogyne angustifolia* var. *angustifolia* has fleshy fruit which may facilitate dispersal by birds (Carlquist 1980, p. 96; USFWS 1993, p. 17; Lindqvist and Albert 2002, p. 1710). Carlquist (1980, p. 96) and Lindqvist and Albert (2002, p. 1710) indicated that bird dispersal of seeds is common on the islands, and other mint taxa appear to be dispersed by birds.

Aslan et al. (2018, p. 1) conducted a study to see if *S. angustifolia* var. *angustifolia* is ecologically extinct even though it is still present in the wild. An organism is said to have become ecologically extinct if it becomes rare enough that it no longer participates in certain interspecific interactions even though it is still present. This form of extinction may have ramifications for ecological community function. The robust size and open shape of *S. angustifolia* var. *angustifolia* flowers, along with their high accessibility, visibility, and nectar content, suggest that they are adapted to animal-mediated pollination. However, only one flower visitor was observed at the focal high-elevation study site: an individual of the non-native sweat bees (*Lasioglossum impavidum*). Experimental pollination treatments indicate that *S. angustifolia* var. *angustifolia* is self-compatible and demonstrates some autogamy, setting fruit and seed in the absence of pollinators. However, experimental additions of pollen increased fruit production,

indicating that plants are pollen-limited and that lack of pollinators carries a reproductive cost for this species. Ecological communities throughout Hawai‘i are highly modified and the distribution and diversity of the native pollinator community that occurred with *S. angustifolia* var. *angustifolia* are wholly unknown. Nevertheless, the lack of visitation by native pollinators and extremely rare visitation by non-native pollinators suggest that individuals of *S. angustifolia* var. *angustifolia* are contributing little to pollination networks in its high-elevation habitat (Aslan et al. 2018, p. 1).

Vegetative cloning is an important means of reproduction. Shoots root at leaf nodes, ultimately forming independent plants. Plants also spread by a network of rhizomes. Because *Stenogyne angustifolia* var. *angustifolia* propagates by rhizomes, stolons, and aerial shoots, it is difficult to define individual plants. Consequently, it is difficult to estimate true population sizes (USFWS 1993, p. 17).

This species was noted to hybridize with the sympatric *Stenogyne rugosa* (ma‘ohi‘ohi) and *S. microphylla* in the Kīpuka Kalawamauna Endangered Plant Habitat, where individuals of *S. angustifolia* var. *angustifolia* were occasionally noted with more than two flowers at each node, a feature more characteristic of *S. rugosa* (Shaw and Castillo 1997, p. 105; USFWS 2012, pp. 6–7).

Individual Needs

Stenogyne angustifolia var. *angustifolia* is typically found in the Pōhakuloa Plateau, which is an area composed of a basaltic plain that is located between 5,000 to 6,000 ft (1,500 to 1,800 m) elevation between Mauna Kea, Mauna Loa, and Hualālai (USFWS 2012, p. 10). The substrate is derived from very old Mauna Kea ‘a‘ā and pāhoehoe lava flows that are more than 10,000 years old (Shaw and Castillo 1997, p. 105; USFWS 2012, p. 10). Highest densities of this species are found on pu‘u (cinder cones) and on tumuli (small hills) at Pōhakuloa Training Area (PTA) (USFWS 1993, p. 7; USFWS 2012, p. 10). Associated plant communities include *Euphorbia* sp. (‘akoko) forest, open *Metrosideros* sp. (‘ōhi‘a) forest with sparse and dense shrub understory, *Metrosideros sp.* mixed forest, open and mixed *Dodonaea viscosa* (‘a‘ali‘i) shrublands, *Myoporum sandwicense-Dodonaea viscosa* (naio- ‘a‘ali‘i) shrublands, *Myoporum sandwicense-Sophora chrysophylla* (naio-māmane) mixed shrublands, *Myoporum* shrublands, and *Leptecophylla tameiameiae* (pukiawe) mixed shrublands (Shaw and Castillo 1997, p. 105; USFWS 2012, p. 10). At PTA, associated native plant species include *Bidens menziesii* (ko‘oko‘olau), *Chenopodium oahuense* (‘āweoweo), *Coprosma montana* (pilo), *Eragrostis atropioides* (lovegrass), *Lipochaeta subcordata* (nehe), *Osteomeles anthyllidifolia* (‘ulei), *Panicum tenuifolium* (pili), *Sida fallax* (‘ilima), and *Wikstroemia phillyreifolia* (‘ākia) (Shaw and Castillo 1997, p. 105; USFWS 2012, p. 10).

Suitable habitat for *Stenogyne angustifolia* var. *angustifolia* consists of native dry forests, dry shrubland, mesic forest, and mesic shrubland. This species formally occupied dry subalpine shrubland habitat, a subtype of dry shrublands on all three islands. Dry subalpine shrublands occur on sandy-loamy soils derived from volcanic ash or sand, or weathered lava and have a seasonal climate with drought conditions during the summer months of May to October; rainfall mostly occurs in the winter months of November to March. This habitat experiences extremely dry and cold climate, with frequent frost that occurs even in summer months (Pe‘a et al 2020, pp. 2–3).

Characteristics of these ecosystems are described in the Hawaiian Islands Dry Forest habitat status assessment (Javar-Salas et al. 2019, pp. 2–3), Hawai‘i Dry Grasslands and Shrublands habitat status assessment (Pe‘a et al. 2019, pp. 2–3), Hawai‘i: Mesic Forest habitat status assessment (Lowe et al. 2019, pp. 2–3), and Hawai‘i: Mesic Grasslands and Shrublands habitat status assessment (Ball et al. 2019, pp. 2–3).

There are known differences in soil types between *Stenogyne angustifolia* var. *angustifolia* population units on the different islands. *Stenogyne angustifolia* var. *angustifolia* on the island of Hawai‘i are generally found in weathered ‘a‘ā or pāhoehoe basaltic lava flow substratum, very stony land, rock land, and in rare occasions, in extremely gravelly sand, extremely rocky muck, or rough broken land. Maui and Moloka‘i populations occurred in silt loam to rocky silty clay loam. Table 1 list known wild population units of *S. angustifolia* var. *angustifolia* with a variety of habitat characteristics (USFWS 2020b, unpublished data). There are known differences in elevation, average rainfall, and slope between known populations of *S. angustifolia* var. *angustifolia.* Across its range, this species occurred at elevations from 194 ft (59 m) to 6,591 ft (2,009 m), with annual rainfall between 200 in (523mm) to 803 in (2,039 mm) and on slopes of 0 to 52 percent (no slope to moderate slope).

Table 1. Known wild population units of *Stenogyne angustifolia* var. *angustifolia* with habitat type, slope, soil type, and annual rainfall.

Population Unit Letter	**Population Unit Name**	**Habitat Type**	**Elevation Feet (meter)**	**Average Annual Rainfall Inches (Centimeter)**
Hawai‘i				
A	Pali O Ka Eo	mesic shrublands	3,609 (1,100)	437 (1,110)
B	Kahuku East	mesic shrublands	6,591 (2,009)	803 (2,039)
C	Ka‘ū Desert	mesic shrublands	3,911 (1,192)	633 (1,607)
D	Kīpuka Alāla South and North	dry shrublands, dry forest	5,220–5,764 (1,591–1,757)	178–183 (453–465)
E	Mixed Tree Fence South and East	dry shrublands, dry forest	4,816–5,200 (1,468–1,585)	185–191 (470 – 484)
F	Kaūmana - Punahoa	undetermined	302 (92)	1,544 (3,922)
G	Pu‘u Anahulu Māuka 1	dry shrublands	4,344–4,370 (1,324–1,332)	245 (623)
H	Pu‘u Anahulu Māuka 2	dry shrublands	4,281–4,360 (1,305–1,329)	234–241 (594–612)
I	Ka‘ūpūlehu Māuka	mesic shrublands	3,009 (917)	348 (884)
J	Pu‘u Anahulu Māuka- *Stenogyne* Unit	dry shrublands	3,763–3,993 (1,147–1,217)	255–256 (648–649)
K	Nā‘ōhule‘elua- Kīpuka Kalawamauna	dry shrublands, dry forest	4,488–5,545 (1,368–1,690)	194–213 (492–540)
L	Kīpuka Kalawamauna North Fence - Ke‘āmuku	dry shrublands, dry forest	4,918–5,089 (1,499–1,551)	221–225 (561–571)

Population Unit Letter	Population Unit Name	Habitat Type	Elevation Feet (meter)	Average Annual Rainfall Inches (Centimeter)
M	Waikōloa	dry shrublands	3,402 (1,037)	274 (696)
N	Puʻu Kapu	mesic forest	2,995 (913)	598 (1,518)
Maui				
O	ʻāhihi kīnaʻu	dry shrublands	1,791 (546)	269 (683)
P	Waiohuli	mesic shrublands	4,564 (1,391)	319 (810)
Q	Kailua Gulch	mesic shrublands	4,593 (1,400)	669 (1,698)
Molokaʻi				
R	Kalaupapa	dry shrublands	194 (59)	426 (1,083)

Population Needs

To be resilient, a population needs to be healthy, which means it consists of abundant individuals within habitat patches of adequate area and quality. The population also needs to be stable or increasing in population growth and able to maintain survival and reproduction in spite of disturbance. Resiliency is a population ability to reproduce to maintain or increase the numbers of individuals in the population giving the population the ability to withstand stochastic disturbance events. We define resiliency for *S. angustifolia* var. *angustifolia* based on the metric of population size (number of individuals) and population structure (age or size class distribution: presence of seedlings, immature, and mature individuals).

Resilient species have interconnected, healthy populations across a diversity of good quality and quantity of habitat. Resilient populations of *Stenogyne angustifolia* var. *angustifolia* need enough space and suitable habitat, ability to cross-pollinate, and maintain connectivity between populations to persist and survive over many generations. Suitable habitat for populations of *S. angustifolia* var. *angustifolia* on Maui and Molokaʻi occurred in silty loam to rocky silty clay loam habitats within mesic shrubland and dry shrubland habitat types. On the island of Hawaiʻi, suitable habitat occur in dry forest, dry shrubland, mesic forest, and mesic shrubland habitat types.

Species Needs and Ecology

Stenogyne angustifolia var. *angustifolia* occurred within four habitat types (dry forest, dry shrubland, mesic forest, mesic shrubland) on the island of Hawaiʻi (Table 1). The extant population units are fairly confined to the Pōhakuloa Plateau, which is an area composed of a basaltic plain that is located between 5,000 to 6,000 ft (1,500 to 1,800 m) elevation between Mauna Kea, Mauna Loa, and Hualālai (USFWS 2012, p. 10). The population units at Kahuku East, Kaʻū Desert, and Kaʻūpūlehu Māuka occurred in mesic shrubland while the population unit in Puʻu Kapu was the only population that occurred in mesic forest habitat on Hawaiʻi Island. Most of the population units for *S. angustifolia* var. *angustifolia* occur in dry shrubland or dry forest or a combination of both habitat types. Populations on Maui and Molokaʻi occurred in mesic shrubland and dry shrubland. These populations were last observed in the 1800's (HMBP 2010).

Redundancy is having more than one resilient population distributed across the landscape increasing the ability of a species to withstand catastrophic events. We define redundancy for *Stenogyne angustifolia* var. *angustifolia* based on the metrics of the number of populations and the species distribution across the landscape or the proximity of the population to one another. As assessed, there were 18 known wild populations of *S. angustifolia* var. *angustifolia* that occurred within four habitat types: mesic or dry shrubland on Maui and Molokaʻi and dry forest, dry shrubland, mesic forest, and mesic shrubland on Hawaiʻi. Currently, there are five extant populations of this species that occur in dry forest and shrubland habitat on Hawaiʻi.

Representation is defined as ecological diversity secured throughout multiple populations across the range of the species, therefore, increasing ability to adapt to change. We evaluated representation of *Stenogyne angustifolia* var. *angustifolia* on the number of populations representing each known habitat type on each island. The two populations on Maui occupied mesic shrublands habitat and one population occupied dry shrublands habitat; the population on Molokaʻi occupied dry shrubland habitat. Four populations on Hawaiʻi occupied mesic shrubland habitat and one occupied mesic forest habitat. Four populations occupied a combination of dry forest and shrubland habitat, four populations occupied dry shrbland habitat, and one population habitat is unknown due to a very low accuracy point of a 5 mile radius.

FACTORS INFLUENCING VIABILITY

Threats

The immediate and potential threats facing *Stenogyne angustifolia* var. *angustifolia* include the destruction and adverse modification of habitat by feral ungulates, habitat modification and competition with non-native plants, herbivory by feral ungulates, military activities, fire (USFWS 1979, p. 62,468; USFWS 2012, p. 12), hybridization, climate change, drought, and inadequacy of regulatory mechanisms (USFWS 2012, p. 12; USFWS 2020a, p. 13). Hawaiian Islands Dry Forest habitat status assessment (Javar-Salas et al. 2020, pp. 11–14), the Hawaiʻi Dry Grasslands and Shrubland habitat status assessment (Peʻa et al. 2020, pp. 9–10), the Hawaiʻi: Mesic Forests habitat status assessment (Lowe et al. 2020, pp. 13–17), and the Hawaiʻi: Mesic Grasslands and Shrublands habitat status assessment (Ball et al. 2020, pp. 9–16) should be referred to for further description and discussion of threats for dry forest, dry shrubland, mesic forest, and mesic shrubland on Molokaʻi, Maui, and Hawaiʻi.

Herbivory by feral ungulates

It was originally thought that *Stenogyne angustifolia* var. *angustifolia* did not appear to be highly palatable to feral sheep (*Ovis aries*) and goats (*Capra hircus*) and appeared to be consumed only during the driest periods or after fire. However, later observations on the abundance of individuals found within large-scale fenced units and their relative scarcity outside of fenced units suggested that this species is in fact impacted by ungulates, and that browse is not commonly observed for the species because individuals are probably uprooted and completely consumed by ungulates (USFWS 1979, p. 62,468; USFWS 1993, pp. 18–19; USFWS 2012, pp. 11–12). Shaw and Castillo (1997, p. 105) noted that rooting activities by feral pigs (*Sus scrofa*) could damage and kill the underground stems of *S. angustifolia* var. *angustifolia* (USFWS 2012, p. 10).

Destruction and degrdation of habitat by feral ungulates
Feral sheep, goats, and pigs modify and destroy the habitat of *S. angustifolia* var. *angustifolia*. The effects of these nonnative animals include the destruction of vegetative cover, trampling of plants and seedlings, soil disturbance, dispersal of alien plant seeds on hooves and coats and through the spread of seeds in feces, and creation of open, disturbed areas conducive to further invasion by nonnative pest plant species (USFWS 1979, p. 62,468; Cuddihy and Stone 1990, pp. 63–64; USFWS 1993, pp. 18–19; USFWS 2012, pp. 11–12). All of these impacts lead to the subsequent conversion of native plant communities to plant communities dominated by nonnative species.

Habitat degrdation and competition with non-native plants
Invasive plant species are a threat to *Stenogyne angustifolia* var. *angustifolia* as they have the ability to compete with the species for water, space, nutrients, and light. Invasive nonnative plant species are responsible for modifying the availability of light; altering soil-water regimes; modifying nutrient cycling; altering the fire regime affecting native plant communities; and ultimately, converting native-dominated plant communities to nonnative plant communities (Smith 1985, pp. 180–181; Cuddihy and Stone 1990, p. 74; D'Antonio and Vitousek 1992, p. 73; Vitousek et al. 1997, p. 6; USFWS 2012, p. 10). Invasive plant species include *Pennisetum setaceum* (fountain grass), *Senecio madagascariensis* (fireweed), *Tagetes minuta* (stinkweed), and *Verbascum thapsus* (mullein) (USFWS 2012 p, 10). *Delairea odorata* (German ivy) and *Stellaria media* (common chickweed) are present at the Pu'u Huluhulu reintroduction site and *Kalanchoe tubiflora* (chandelier plant) was found at PTA sites (USFWS 2012, p. 12). Invasive grasses such as *Cenchrus ciliaris* (buffel grass) and *Cenchrus clandestinus* (kikuyu grass) are present at PTA and are fast growing, producing a large volume of seeds (Perkins et al. 2018, p. 2).

Military activities
Some populations at PTA are impacted by Army training activities. These include construction of military facilities, building new roads and maintaining old roads, and military maneuvers (USFWS 1979, p. 62,468; USFWS 1993, p. 18; USFWS 2012, p. 12).

Fire
PTA has frequent fires, primarily the result of military maneuvers, and occasionally as a result of lightning or volcanic eruptions. Fire at PTA can be sustained by the vegetation at any time of the year (USFWS 1979, p. 62,468; USFWS 1993, p. 20; USFWS 2012, p. 12). *Stenogyne angustifolia* var. *angustifolia* is at risk of negative impacts by fire because its habitat is located in or near areas that were burned in previous fires. The threat from fire is serious and ongoing to this species because fire damages and destroys native vegetation and individual plants of *S. angustifolia* var. *angustifolia*, including dormant seeds, seedlings, and juvenile and adult plants. In July of 2018, a wildland fire was started when a U.S. Marine Corps H-1 aircraft inadvertently discharged flares while the aircraft was at approximately 500 ft (152 m) above ground level over a training area. The fire burned approximately 368.4 acres (ac) (149.1 hectares (ha)) at varying intensities resulting in a patchwork of fully or partially burned and unburned areas. About 43 percent of *S. angustifolia* var. *angustifolia* locations were within the burned area (part of Population G inlcuding Kipuka Kalawamauna East and North). Five percent of the plant locations were lost (from 204 locations pre-fire to 193 locations post-fire). Re-sprouting from

below-ground rhizomes and seeds in the soil seed bank occurred in the protected fenced area, immediately increasing the number of individuals monitored. The response of the population to this fire, particularly with respect to the fate of these individuals, is continuing to be monitored (CEMML 2020, p. 11). Beavers and Burgan noted that *S. angustifolia* var. *angustifolia* seeds re-sprout and regenerate after fire if precipitation occurs; however, the effects of frequent and more severe fires are unknown and could affect plant health and the seed bank (USFWS 2012, p. 7).

Drought

Drought causes the direct loss of individuals due to lack of moisture, which leads to death. In addition, drought causes the loss or degradation of habitat due to death of individual native plants, as well as an increase in forest and brush fires of drought tolerant nonnative species. During a drought, feral ungulate consumption and trampling of vegetation promotes erosion by destabilizing substrate and creating gullies that convey water, and dislodging stones from ledges that can cause rockfalls and landslides (Cuddihy and Stone 1990, pp. 63–64). Although all habitats are susceptible to drought, habitat with rock-land soils are highly susceptible (Sato et al. 1972, p. 51). Additional information related to the stressors of drought as it relates to changes in water availability and vegetation composition can be found in Javar-Salas et al. (2019, entire) and Pe‘a et al. (2019, entire), respectively. These threats are serious and have the potential to occur at any time, although their occurrence is not predictable.

Hybridization

Hybridization is considered a threat to *Stenogyne angustifolia* var. *angustifolia* because it can lead to the loss of the species. Putative hybrids of *S. angustifolia* with *S. rugosa* were observed at PTA (Weller and Sakai 1990, pp. 831–843; USFWS 2012, p. 12). Hybridization is a phenomenon of cross-pollination between two species in which there is a transfer of genetic information between the two species (introgression). This can lead to the formation of a new species or a decline or loss of a genetically-distant taxon. If one of the two hybridizing species are more abundant or vigorous than the other, and the hybrid individuals are also vigorous, the rarer species could become extinct after several generations of outcrossing and backcrossing among the other parent species and the hybrids. *Stenogyne angustifolia* var. *angustifolia* hybridized with both *S. rugos*a and *S. microphylla* at PTA. Within the the Kīpuka Kalawamauna Endangered Plant Habitat, individuals of *S. angustifolia* var. *angustifolia* occasionally have more than two flowers at each node, a feature more characteristic of *S. rugosa* (Shaw and Castillo 1997, p. 105; USFWS 2012, pp. 6–7).

Climate change

Climate change may pose a threat to *Stenogyne angustifolia* var. *angustifolia*. Fortini et al. (2013, entire) conducted a landscape-based assessment of climate change vulnerability for native plants of Hawai‘i using high resolution climate change projections. Climate change vulnerability is defined as the relative inability of a species to display the possible responses necessary for persistence under climate change. This assessment concluded that *S. angustifolia* is vulnerable to the impacts of climate change, with a vulnerability score of 0.306 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change).

Inadequate Regulatory Mechanisms

Inadequate Habitat Protection
Nonnative feral ungulates pose threat to *Stenogyne angustifolia* var. *angustifolia* through destruction and degradation of the species' habitat and herbivory but regulatory mechanisms are inadequate to address this threat (USFWS 1979, pp. 62,468–62,469). The State of Hawai‘i provides game mammal (feral pigs, goats, and mouflon sheep) hunting opportunities on 38 State-designated public hunting areas on the island of Hawai‘i (HDLNR 2015, pp. 19–21 and 66–77). However, the State's management objectives for game animals range from maximizing public hunting opportunities (e.g., "sustained yield") in some areas to removal by State staff, or their designees, in other areas (HDLNR 2015, entire).

Introduction of Nonnative Plants and Insects
Currently, four agencies are responsible for inspection of goods arriving in Hawai‘i (USFWS 1979, pp. 62,468–62,469). The Hawai‘i Department of Agriculture (HDOA) inspects domestic cargo and vessels and focuses on pests of concern to Hawai‘i, especially insects or plant diseases. The U.S. Department of Homeland Security-Customs and Border Protection (CBP) is responsible for inspecting commercial, private, and military vessels and aircraft and related cargo and passengers arriving from foreign locations (USFWS 1979, pp. 62,468–62,469). The U.S. Department of Agriculture-Animal and Plant Health Inspection Service-Plant Protection and Quarantine (USDA-APHIS-PPQ) inspects propagative plant material, provides identification services for arriving plants and pests, and conducts pest risk assessments among other activities. (HDOA 2009, p. 1). The Service inspects arriving wildlife products, enforces the injurious wildlife provisions of the Lacey Act (18 U.S.C. 42; 16 U.S.C. 3371 *et seq*.), and prosecutes CITES (Convention on International Trade in Wild Fauna and Flora) violations. The State of Hawai‘i allows the importation of most plant taxa, with limited exceptions (USFWS 1979, pp. 62,468–62,469). It is likely that the introduction of most nonnative invertebrate pests to the State has been and continues to be accidental and incidental to other intentional and permitted activities. Many invasive weeds established on Hawai‘i have currently limited but expanding ranges. Resources available to reduce the spread of these species and counter their negative ecological effects are limited. Control of established pests is largely focused on a few invasive species that cause significant economic or environmental damage to public and private lands, and comprehensive control of an array of invasive pests remains limited in scope (USFWS 1979, pp. 62,468–62,469).

Conservation Actions
Several agencies and organizations are involved with conservation activities for *Stenogyne angustifolia* var. *angustifolia*. Conservation measures consist of surveys, monitoring of populations, collecting and storing seeds, propagating plants at nurseries, translocating propagated plants into the field, fencing, ungulate eradication efforts, and invasive weed control. These measures are being conducted by staff at the Pōhakuloa Training Area, Hawai‘i Volcanoes National Park, State of Hawai‘i Department of Land and Natural Resource (DLNR)-Division of Forestry and Wildlife (DOFAW) Nāpu‘u Conservation Project, Volcano Rare Plant Facility, the National Tropical Botanical Garden, and the National Laboratory for Genetic Resources Preservation.

Pōhakuloa Training Area (PTA)
Surveys conducted between 2011–2015 recorded a minimum of 2,517 *Stenogyne angustifolia* var. *angustifolia* individuals within 1,087 montioring plots on PTA, and an overall estimate of 4,501 wild individuals (CEMML 2018, p. 4; CEMML 2020, p. 8).

Seeds were collected from wild populations (2,175 seeds), from the PTA greenhouse (1,926 seeds), and from translocated populations (119 seeds) (CEMML 2018, p. 4; CEMML 2019, p. 10; CEMML 2020, p. 37). In 2019, germination trials were initiated on 73 seeds, and currently ongoing (CEMML 2019, p. 10; CEMML 2020, pp. 40, 119–120).

Since 2005, several hundred plants representing 28 wild individuals have been propagated at the PTA nursery for outplanting and living collection purposes. Two hundred and forty-five individuals were translocated into five sites both on and off PTA (CEMML 2017, p. 101). As of 2019, 186 remain (CEMML 2020, pp. 48–49), and three sites on PTA have seen reproduction via vegetative propagation, though they are not all currently extant (CEMML 2017, p. 101; 2020, pp. 48–49).

The PTA is actively working to control and eradicate invasive plants through the Invasive Plants Program under the PTA Natural Resources Office. This program is comprised of three sections: vegetation control by mechanical removal and herbicide application (CEMML 2016, p. 165), fuel break management, and invasive plants survey and monitoring. The program not only controls invasive plants but works to reduce the fire fuel created by invasive plants. Additional actions include the implementation and maintenance of fire breaks, fuel breaks, and fuel monitoring corridors (CEMML 2016, pp. 83–84).

In 2013, 14 conservation fence units were installed in PTA encompassing 15,300 ha of dryland habitat. Ungulate eradication efforts continued off and on through the next few years until a new plan was established in an effort to create an uninterrupted enforcement of removal. By 2017, all conservation fence units were considered ungulate free (Fleishman 2019, p. 1). Today, fences are maintained through the Fence Maintenance Project run by the PTA Natural Resources Office. All populations of *Stenogyne angustifolia* var. *angustifolia* at PTA are within fenced areas.

Hawai‘i Volcanoes National Park (HAVO)
Conservation activities by HAVO staff consist of collecting and storing seeds, propagating plants in their nursery, translocating individuals of *Stenogyne angustifolia* var. *angustifolia* on park property, fencing, and threat control. In 2016, 13 individuals were in storage for controlled propagation purpose at HAVO representing four wild PTA individuals (HAVO 2016), but none currently are maintained in *ex situ* storage (HAVO 2020, p. 4).

In 2004, seeds were collected from a single population at Pu‘u wa‘awa‘a by HAVO staff; 27 seedlings derived from seeds and 91 plants derived from cuttings under propagation, represent about 12 founder lines from PTA (USFWS 2012, p. 13). HAVO reported 16 individuals were reintroduced at Kīpuka Kulalio in the Mauna Loa Special Ecological Area from seeds/cuttings collected at PTA (USFWS 2012, p. 14; HAVO 2019, p. 25). In 2006, 135 plants were outplanted into Kīpuka Mauna‘iu. An additional 53 individuals were outplanted in 2007 but by 2010 less than one percent were alive at either site (HAVO 2019, p. 25). An additional ten plants

comprised of seven founders were transferred from PTA to HAVO in 2012. Two plants were planted in a test site maintained by USGS. As of 2012 one plant remained at the test site in a cage (HAVO 2019, p. 25). For the purposes of this report, we are considering these reintroductions to be likely extirpated.

Fencing for the Kapapala Unit of Hawai‘i Volcanoes National Park is maintained and spans these lava flows where the outplanting was conducted. These locations are not included on the map in Figure 3, and occur Northwest of Population C.

State of Hawai‘i DOFAW Nāpu‘u Conservation Project
Conservation activities by the Hawaii DLNR-DOFAW staff consist of collecting and storing seeds, propagating plants in their nursery, translocating individuals of *Stenogyne angustifolia* var. *angustifolia* to various restoration sites at Pu‘u wa‘awa‘a, and fencing and monitoring wild populations within the Pu‘u Anahulu Game Management Area (GMA). Since 2002, several hundred plants have been propagated at their nursery for outplanting and living collection purposes. Fifty individuals were translocated to Hauaina/Reservoir Paddock and 20 individuals to Kīpuka ‘Owē‘owē, 15 individuals to Cone Unit Sites, and 120 individuals to Uhiuhi 12-acre USFS plots (Hawai‘i DLNR-DOFAW 2016, 2018). The majority of wild plants within the GMA are fenced in two separate units (*Stenogyne* Unit J; see Figure 3) and Anahulu 1 (part of K), but two locations remained unfenced (G and H).

Volcano Rare Plant Facility
The Volcano Rare Plant Facility has been propagating *Stenogyne angustifolia* var. *angustifolia* from two Pu‘u wa‘awa‘a founders for outplanting efforts and to maintain a living collection since 2013 (Volcano Rare Plant Facility 2019). Between 2013 and 2018, 24 plants were propagated and 19 individuals were used for outplanting (Volcano Rare Plant Facility 2013, 2014, 2015, 2018).

National Tropical Botanical Garden (NTBG)
The NTBG’s focus is on identifying, documenting, understanding, and conserving the rich diversity of tropical plants and their habitats. Their collections (living, herbarium, and library) provide rich resources. The NTBG’s conservation initiatives include collecting expeditions throughout Hawai‘i and the Pacific region to identify plant species that are at risk of extinction, to collect seeds and plant material for propagation and conservation in the living collections, ecological restoration of degraded habitats, protecting the endemic species that still exist, and reintroducing species which have not survived on their own (*https://ntbg.org/science*). The NTBG’s botanists conduct extensive surveys for rare plant species in areas where wild populations were known to exist historically. As of 2019 the NTBG possesses seeds from one wild PTA individual in storage but viability is unknown due to the length in time that has lapsed since it was received (April 1992) (NTBG 2019).

National Seed Storage Laboratory
Seeds were collected for storage at the National Laboratory for Genetic Resources Preservation at Colorado State University, and occasionally used for seed germination tests (USFWS 2012, p. 13).

Endangered Species Act

The Service in 1979 determined endangered status under the ESA, as amended, for three plants on 1979 including *Stenogyne angustifolia* var. *angustifolia* (USFWS 1979, pp. 62,468–62,469). The primary purpose of the ESA is the conservation of endangered and threatened species and the ecosystems upon which they depend. The ultimate goal of such conservation efforts is the recovery of these listed species, so that they no longer need the protective measures of the ESA. Conservation measures provided to species listed as endangered or threatened under the ESA include recognition of threatened or endangered status, recovery planning, requirements for Federal protection, and prohibitions against certain activities. The ESA encourages cooperation with the States and requires that recovery actions be carried out for all listed species. The ESA and its implementing regulations in addition set forth a series of general prohibitions and exceptions that apply to all endangered wildlife and plants. For plants listed as endangered, the ESA prohibits the malicious damage or destruction on areas under Federal jurisdiction and the removal, cutting, digging up, or damaging or destroying of such plants in knowing violation of any State law or regulation, including State criminal trespass law. Certain exceptions to the prohibitions apply to agents of the USFWS and State conservation agencies. The USFWS may issue permits to carry out otherwise prohibited activities involving endangered or threatened wildlife and plant species under certain circumstances. With regard to endangered plants, a permit must be issued for scientific purposes or for the enhancement of propagation or survival. For federally listed species unauthorized collecting, handling, possessing, selling, delivering, carrying, or transporting, including import or export across State lines and international boundaries, except for properly documented antique specimens of these taxa at least 100 years old, as defined by section 10(h)(1) of the ESA, is prohibited.

Damaging or destroying any of the listed plants in addition is violation of the Hawai‘i State law prohibiting the take of listed species. The State of Hawai’i’s endangered species law (HRS, Section 195-D) is automatically invoked when a species is federally listed, and provides supplemental protection, including prohibiting take of listed species and encouraging conservation by State government agencies. *Stenogyne angustifolia* var. *angustifolia* occurs on both Federal and non-Federal lands.

CURRENT CONDITION

Historical Condition

Pre-human Habitat Distribution and Description

Historical populations of *Stenogyne angustifolia* var. *angustifolia* on the islands of Hawai‘i, Maui, and Moloka‘i occupied dry and mesic forests and shrublands (see Table 1). Dry and mesic forests were more extensive historically, particularly in the lowlands, and contained inclusions of native grasslands and shrublands throughout the areas they occurred. They were comprised of a wide range of species and diversity. This high quality and large size would have helped dry and mesic forests tolerate natural, annual variations in the environment and recover from periodic disturbances (i.e., floods, minor fires, etc.). Should a periodic disturbance have occurred, the soil seed bank likely had a large enough range and diversity of species to allow the dry and mesic forests to recover, thus making them resilient (Javar-Salas et al. 2020, pp. 3–6; Lowe et al. 2020, pp. 3–8).

Dry and mesic shrublands were also more extensive historically and occurred as inclusions within mesic and dry forests; it is likely that shrublands and forests were found together throughout the lowlands. Species richness was considered low to moderate so although it was composed entirely of native vegetation, it may not have been species rich. However, the large size of these habitat in the main Hawaiian Islands made it resilient to stochastic events like flooding or minor fires (Ball et al. 2020, pp. 2–3; Pe‘a et al. 2020, pp. 3–5). We refer you to the Pre-Human Condition section of the habitat status assessments for mesic grassland and shrubland (Ball et al. 2020, pp. 2–3), mesic forest (Lowe et al. 2020, pp. 3–8), dry forest (Javar-Salas et al. 2020, pp. 3–8) and dry grassland and shrubland (Pe‘a et al. 2020, pp. 3–5) for further discussion on the pre-human habitat distribution and description of dry forest, dry shrubland, mesic shrubland, and mesic forest. The two populations on Maui occupied mesic shrublands habitat and one population occupied dry shrublands habitat; the population on Moloka‘i occupied dry shrubland habitat. Four populations on Hawai‘i occupied mesic shrubland habitat and one occupied mesic forest habitat. Four populations occupied a combination of dry forest and shrubland habitat, four populations occupied dry shrubland habitat, and one population habitat is undetermined due to a very low accuracy point of a 5 mile radius.

Historic Trends of Stenogyne angustifolia *var.* angustifolia

Stenogyne angustifolia var. *angustifolia* was observed in 1840 in the Waimea District on the island of Hawai‘i and described by Asa Gray in 1862. This species was last collected in the 1800s on Maui and Moloka‘i. One population was located on the Kalaupapa cliff of Moloka‘i (R on map, see Figure 5) and three populations were found on Maui (Honua‘ula in the ‘Ulupalakua area; Kula; and Hāmākua on the northwestern slope of Haleakalā) (O, P, Q on map, see Figure 4). These four populations are all presumed to be likely extirpated (USFWS 2012, p. 7); they will not be further considered in this species report.

On the island of Hawai‘i, this species was collected in several locations. Collections prior to 1950 are from the Waimea District (1840; Puu Kapu, N (see Figure 3); Ka‘ū, between Kīlauea and Kapapala (1868); Puna (1800s; Kaumana-Punahoa, F); North Kona, Hu‘eh‘ue (1932; Ka‘ūpūlehu Māuka, I); Kahuku (1935; Pali O Ka Eo, A); and the 1859 lava flow at 7,000 ft (2,133 m) elevation (1949) (Kahuku East, B) (USFWS 2012, p. 7). For the Ka‘ū population (C), Hawai‘i Volcanoes National Park reported that the species had not been observed in the park since then, and it was believed to be extirpated from the area (USFWS 2012, p. 7).

Stenogyne angustifolia var. *angustifolia* had not been observed after these discoveries for decades, and was presumed extinct until fewer than 10 individuals were rediscovered in 1977 at Kīpuka Kalawamauna (K), located on the northwestern side of the U.S. Army’s PTA (USFWS 1993, p. 15), and has remained the largest extant population for the species as of 2019 (CEMML 2020). The range of the species within PTA extends from the southern part of the Ke‘amūku Parcel and Pu‘u Keekee, through Kīpuka Kalawamauna, and south to Kīpuka Alāla (Shaw and Castillo 1997, pp. 105, 108; USFWS 2012, p.7).

Post-1977 collections outside of PTA have been made at Waikōloa (M) and Pu‘u Anahulu 1 (G) (Shaw and Castillo 1997, pp. 105, 108; USFWS 2012, p. 7), but have not been monitored as of 2003. The Waikōloa collection was made in September 1985 (*Hobdy 2451*) from the edge of the Ke‘amūku lava flow in Waikōloa, southwest of Pu‘u Heewai, at about 3,400 ft (1,035 m)

elevation, and consisted of up to a few dozen individuals in four or five spots on very old lava (USFWS 2012, pp. 7–8). The Puʻu Anahulu collection was made in August 1978 (*Warshauer and McEldowney FRW 2103*) in the Puʻu Anahulu ahupuaʻa, northeast of Puʻu Nahaha and east of Hainoa and Kalamalu, at about 4,300 ft (1,310 m) elevation, and consisted of three small individuals (USFWS 2012, p. 8).

In 1993, when the draft recovery plan for *Stenogyne angustifolia* var. *angustifolia* was completed (USFWS 1993, entire), 7 to 14 occurrences were known to occur at PTA within a 5,000 ac (2,000 ha) area, and all appeared to be healthy. No estimates were provided for numbers of individuals, but two of the populations contained more than 100 individuals (USFWS 1993, p. 15). Shaw and Castillo (1997, pp. 105, 108) estimated over 100,000 individuals at PTA, but Steve Evans recalculated those estimates at PTA to be 5,000 to 7,500 individuals within 5 to 15 occurrences (USFWS 2012, p. 8). One possible reason for the variation in estimates resides in the growth habit of *S. angustifolia* var. *angustifolia*, which can make it difficult to estimate true population sizes. Shoots of *S. angustifolia* var. *angustifolia* recline and trail on the ground, then root at the nodes and produce shoots, which can appear to be independent plants. The species also spreads by a network of rhizomes, and a patch of apparently several individuals may actually be vegetative growth from a single genetic individual (USFWS 1993, p. 17; USFWS 2012, p. 8).

In 2002, 11 additional individuals from three locations were discovered in the southern corner of the Keʻamūku Parcel, located to the northwest of Kīpuka Kalawamauna (L). Between July 2003 and December 2005, over 900 new individuals at more than 300 new monitoring plots (5 m radius) were found at PTA, for a grand total of more than 1,300 individuals of *S. angustifolia* var. *angustifolia* at over 400 different monitoring plots, mostly concentrated in the vicinity of Nāʻōhuleʻelua-Kīpuka Kalawamauna (Kīpuka Alāla South and North (D), Mixed Tree Fence South and East (E), and Kīpuka Kalawamauna (K) (CEMML 2016, pp. 16–17; USFWS 2012, p. 8; USFWS 2020b). At the end of 2007, the census at the PTA was 1,684 to 1,936 individuals.

In 2004, 73 *Stenogyne angustifolia* var. *angustifolia* individuals in three populations were found at Puʻu Anahulu Game Management Area (G,H, and J on Table 2) (USFWS 2012, p. 13; USFWS 2020b, unpublished data). Table 3 lists known wild population units of *S. angustifolia* var. *angustifolia*. Figures 3–5 show the distribution of *S. angustifolia* var. *angustifolia* on the islands of Hawaiʻi, Maui, and Molokaʻi.

In summary, the population units on Maui and Molokaʻi are considered possibly extirpated (O, P, Q, R). The loss of these populations has reduced historical redundancy under the current recognized taxonomy for *Stenogyne angustilfolia*, but would have no effect on redundancy for the listed entity of *S. angustifolia* var. *angustifolia*, as it was only ever known from the island of Hawaiʻi, despite no longer being recognized as a taxon. The following populations units on the island of Hawaiʻi are considered historic and possibly extirpated: Pali O Ka Eo (A), Kahuku East (B), Kaʻū Desert (C), Kaumana-Punahoa (F), Puʻu Anahulu Māuka 1 (G), Kaʻūpūlehu Māuka (I), Kīpuka Kalawamauna North Fence (L), Waikōloa (M), and Puu Kapu (N). The island of Hawaiʻi is the historic range of the listed entity, and therefore this decline in redundnacy does not differ among the current taxonomy and listed entity. In total, nine out of 14 known wild populations on the island of Hawaiʻi are possibly extirpated and considered historic.

Table 2. Known wild population units of *Stenogyne angustifolia* var. *angustifolia*.

Population Unit Letter	**Population Unit Name**	**Last Observation Date**	**Extant (Y/N)**	**Estimated Number of Individuals**
Hawai‘i Island				
A	Pali O Ka Eo	1935	N	1
B	Kahuku East	1949	N	1
C	Ka‘ū Desert	1868	N	1
D	Kīpuka Alāla South and North	2012*	Y	1
E	Mixed Tree Fence South and East	2015*	Y	38
F	Kaūmana - Punahoa	1800	N	1
G	Pu‘u Anahulu Māuka 1	2003	N	3
H	Pu‘u Anahulu Māuka 2	2005	Y	25
I	Ka‘ūpūlehu Māuka	1932	N	1
J	Pu‘u Anahulu Māuka-*Stenogyne* Unit	2018	Y	41
K	Nā‘ōhule‘elua-Kīpuka Kalawamauna	2011–2015*	Y	2,478
L	Kīpuka Kalawamauna North Fence - Ke‘āmuku	2002	N	11
M	Waikōloa	2003	N	24
N	Pu‘u Kapu	1840	N	1
Maui				
O	‘Āhihi Kīna‘u	1800	N	1
P	Waiohuli	1800	N	1
Q	Kailua Gulch	1800	N	1
Moloka‘i				
R	Kalaupapa	1800	N	1

*****Based on surveys conducted between 2011–2015 with a minimum of 2,517 *Stenogyne angustifolia* var. *angustifolia* individuals within 1,087 monitoring plots on PTA (CEMML 2020, p. 8).

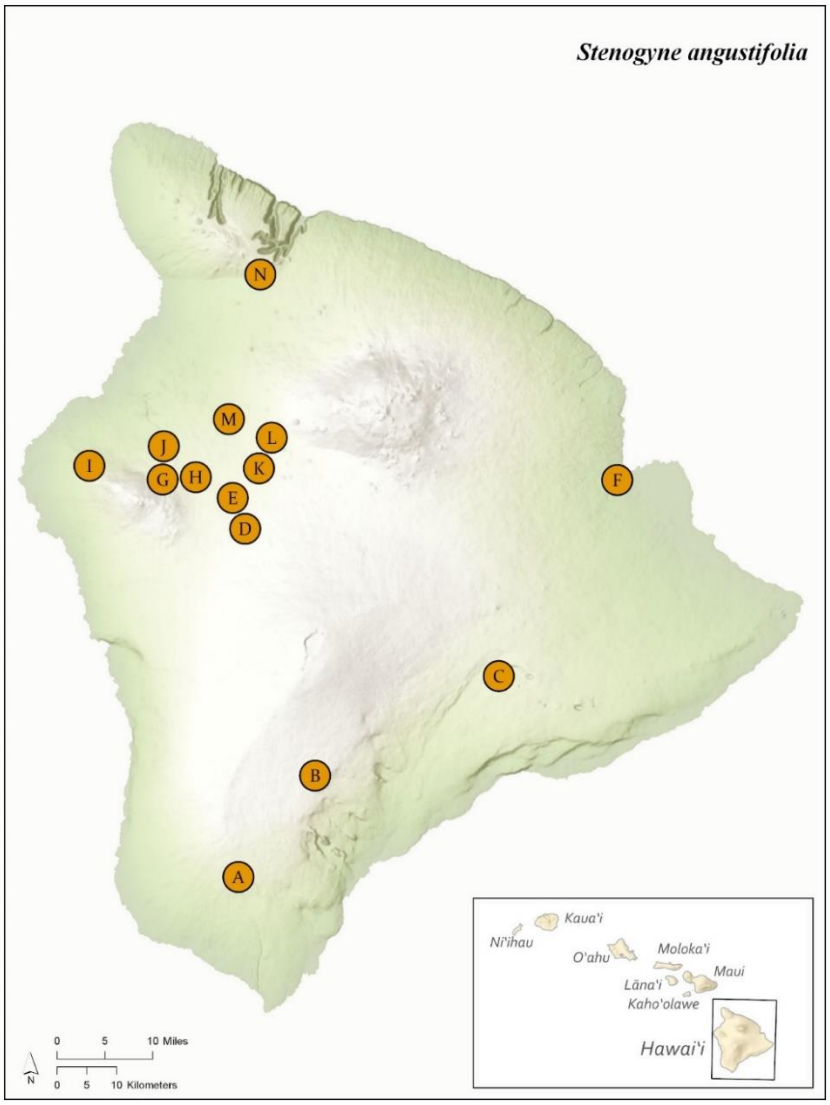

Figure 3. Current and Historic Distribution of *Stenogyne angustifolia* var. *angustifolia* on Hawai‘i Island.

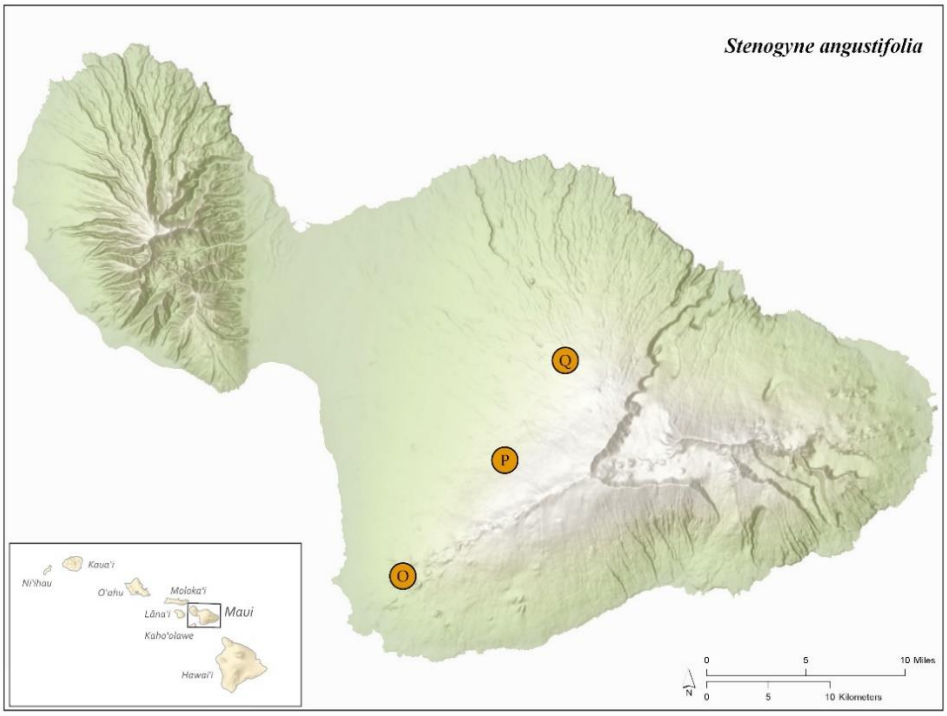

Figure 4. Historic collections of *Stenogyne angustifolia* on Maui.

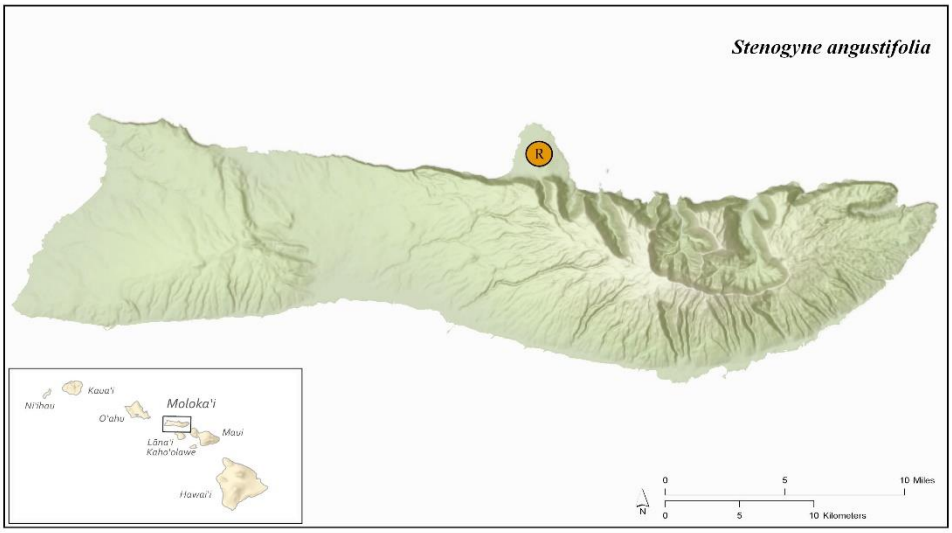

Figure 5. Historic collections of *Stenogyne angustifolia* on Mōlokaʻi.

Current Condition

Currently, dry forests are in decline, both in size and quality of diverse native species, due to threats of invasive ungulates, plants, and herbivores, plant disease, fire, drought, natural disasters, climate change, and agriculture and urban development. 45 percent of the dry forest plant species in Hawaiʻi are at risk of endangerment. 25 percent of the endangered plant taxa in

the Hawaiian Islands are from the dry forests, and approximately 20 percent of dry land plant taxa in the Hawaiian Islands are known to be extinct which has reduced the representation of this forest (Javar-Salas 2020, p. 9).

Dry shrublands are in decline, both in size and quality of diverse native species, due to threats of invasive ungulates, plants, and herbivores, fire, drought, natural disasters, climate change, and agriculture and urban development. One factor contributing to these changes are the introductions of nonnative species, which resulted in new sub-types referred to as introduced grasslands and shrublands that were likely once forest. There are still remnants of native-dominated dry grasslands and shrublands but they are greatly reduced in size, as introduced grasslands and shrublands have become very widespread (Peʻa et al. 2020, p. 8).

Mesic forest and shrubland are in decline due to threats of invasive ungulates, plants, and herbivores, plant disease, fire, drought, natural disasters, climate change, and agriculture and urban development. It is estimated that only 40 percent of the original mesic forest habitat and 10 percent of the original native vegetation of mesic shrubland in the Hawaiian Islands currently remain. Much of the lowland mesic forest and shrubland have since been converted to pasture, military or agricultural use, or have been lost to urbanization or fire. Intensive human disturbance in the lowlands and shrubland has resulted in the majority of intact native mesic forests and shrubland remaining only at higher elevations (Ball et al. 2020, p. 9; Lowe et al. 2020, p. 8).

As of 2019, 3,238 wild individuals are estimated, with 2,517 as a minimum based on surveying techniques to occur at PTA in three populations (CEMML 2020, p. 8) and 92 wild individuals within Puʻu Anahulu GMA in two additional populations plus one shared population (K) with PTA (Hawaiʻi DLNR-DOFAW 2020a). Counts have not been revised in the Puʻu Anahulu populations, but many plants were observed in 2018 (Hawaiʻi DLNR-DOFAW 2020b). The population at Nāʻōhuleʻelua - Kīpuka Kalawamauna (K) contains juvenile and adult individuals while populations at Kīpuka Alāla South and North (D), Mixed Tree Fence South and East (E), Puʻu Anahulu Māuka 2 (H), and Puʻu Anahulu Māuka *Stenogyne* Unit (J) have a lower number of individuals and may not consists of all the different life stages. In summary, there are five extant wild populations totaling an estimate of 3,330 individuals of *Stenogyne angustifolia* var. *angustifolia*. Three extant populations occupy dry forest-dry shrubland habitat and two extant populations occupy dry shrubland habitat.

Some representation is maintained in *ex situ* seed storage and translocated individuals produced from vegetative propagation and seeds to PTA, property managed by DLNR-DOFAW, and Hawaiʻi Volcanoes National Park. Twenty eight founders are represented in *ex situ* seed storage at PTA and two founders from State lands are represented at the Volcano Rare Plant Facility. Two of the translocation sites by PTA are considered successful, where natural recruitment of at least 50 individuals occurred (CEMML 2019, p. 16). Currently, there are approximately 186 individuals remaining at these two sites, one at PTA and another at Puʻu waʻawaʻa. There are four additional translocation sites near Puʻu waʻawaʻa established by DLNR-DOFAW staff, though it is uncertain how many remain at these locations.

SPECIES VIABILITY SUMMARY

Resiliency

For *Stenogyne angustifolia* var. *angustifolia* to maintain viability, the population must be resilient. The definition of resiliency is the capability of a population to reproduce and regenerate in order to maintain or increase the numbers of individuals in the population, giving the population the ability of the population to withstand stochastic events.

We determine resiliency for *Stenogyne angustifolia* var. *angustifolia* based on the metrics of the population size and structure. There are three populations consisting of a minimum of 2,517 and estimate of 3,238 wild individuals at PTA and 92 wild individuals at three populations managed by the State of Hawai‘i, with one population, Nā‘ōhule‘elua - Kīpuka Kalawamauna (K), having individuals on both PTA and DOFAW property. Resiliency for the population at Nā‘ōhule‘elua - Kīpuka Kalawamauna is low to moderate. Although this population has the largest number of individuals representing adults and juveniles, it also has recently burned in 2018, when 1,263 individuals were lost, due to miltary activities, and resiliency from the fire is currently being monitored (CEMML 2020, pp. 48–49). The other populations, Kīpuka Alāla South and North (D), Mixed Tree Fence South and East (E), Pu‘u Anahulu Māuka 2 (H), and Pu‘u Anahulu Māuka *Stenogyne* Unit (J), may have low resiliency due to their lower numbers of individuals and limited number of individuals at difference life stages at each population. Overall, the species is considered to have low resiliency, due to low numbers of individuals and lack of different life stages at four populations. Although the Nā‘ōhule‘elua - Kīpuka Kalawamauna population consists of adult and juvenile individuals in moderate quantities the constant threat of fire, drought, and military activities resiliency for this species is low.

Redundancy

We evaluate redundancy for *Stenogyne angustifolia* var. *angustifolia* based on the metric of the number of resilient populations and their proximity to each other across the range of the species. Four out of nine populations on the island of Hawai‘i are considered possibly recently extirpated (Pu‘u Anahulu Māuka 1 (G), Kīpuka Kalawamauna North Fence (L), Waikōloa (M), and Puu Kapu (N)), in addition to the five populations (Pali O Ka Eo (A), Kahuku East (B), Ka‘ū Desert (C), Kaumana-Punahoa (F), and Ka‘ūpūlehu Māuka (I)) likely extirpated historically. Therefore, the range has been substantially reduced both for the current taxon at the species level, as well as for the listed entity, with the large majority of the individuals (96 percent) found at a single population. Currently, there are five extant populations of known wild individuals, three at PTA (D, E, and K) and two additional populations (H, J) within the adjacent Pu‘u Anahulu GMA, with an additional group of individuals located within the Nā‘ōhule‘elua - Kīpuka Kalawamauna population (K), which crosses the property boundary between the two landowners. This species has low to moderate redundancy as most populations have low resiliency and all five populations are located on the Pōhakuloa Plateau, an indication that the range of the species has substantially contracted. While one population is over 7 mi (11 km) away from the main cluster of populations, a single catastrophic event may still be able to impact all populations. And despite the fact that several translocations sites have been created, only two are considered successful, and neither greatly expand the range of the species.

Representation

We define representation for *Stenogyne angustifolia* var. *angustifolia* based on habitat variation within and among the populations. Currently, there are five known extant populations of wild individuals at PTA and Puʻu Anahulu and two self-sustaining translocation sites at PTA. *Stenogyne angustifolia* var. *angustifolia* was known to inhabit dry forest, dry shrubland, mesic forest, and mesic shrubland, but now only occupy dry forest and shrubland habitat within a single narrow, geographic area of Pōhakuloa Plateau. Twenty eight founders are represented in *ex situ* seed storage at PTA, and 2 founders from State lands are represented at the Volcano Rare Plant Facility. Both of these habitat types are at an increased risk of degradation due to climate change, fires, drought, and invasive species. This species historically existed in other habitat types on the islands of Maui and Molokaʻi, but are all presumed to be likely extirpated (USFWS 2012, p. 7). Therefore, representation is low in the current condition.

Species Viability Summary

The current condition of *Stenogyne angustifolia* var. *angustifolia* is described as having approximately 3,238 wild individuals are estimated, with 2,517 as a minimum based on surveying techniques to occur at PTA in three populations (CEMML 2020, p. 8) and 92 wild individuals within Puʻu Anahulu GMA in two additional populations plus one shared population (K) with PTA (Hawaiʻi DLNR-DOFAW 2020a). In summary, there are five extant wild populations totaling an estimate of 3,330 individuals of *S. angustifolia* var. *angustifolia*. Three extant populations occupy dry forest-dry shrubland habitat and two extant populations occupy dry shrubland habitat. Some representation is maintained in *ex situ* seed storage and translocated individuals produced from these collections, lands managed by the State DLNR-DOFAW, and Hawaiʻi Volcanoes National Park. As this species has low resiliency, low to moderate redundancy, and low representation in its current condition, the overall viability of this species is low.

LITERATURE CITED

Aslan, C.E., C.T. Liang, A.B. Shields, and W. Haines. 2018. Absence of native flower visitors for the endangered Hawaiian mint *Stenogyne angustifolia*: Impending ecological extinction? Global Ecology and Conservation 16 pp. 8.

Ball, D.L., S. Lowe, M.K. Reeves, F. Amidon, and S. E. Miller. 2020. Hawaii: Mesic grasslands and shrublands. Editors: M.I. Goldstein and D.A. Della Sala, Encyclopedia of the World's Biomes, Elsevier, 2020.

Carlquist, S. 1980. Loss of competitiveness and other changes. *In* Hawaii: A Natural History, Pacific Tropical Botanical Garden, Honolulu. Pp. 173–177.

[CEMML] Center for the Environmental Management of Military Lands, Colorado State University, Pōhakuloa Training Area Natural Resources Staff. 2016. "Biennial Report for Pōhakuloa Training Area, Island of Hawai'i 01 Oct. 2013 – 30 Sep 2015". Recovery Permit TE-40123A-2. United States Army Garrison, Pōhakuloa Training Area, Natural Resources Program, Hilo, Hawai'i, prepared for the U.S. Army Garrison, Hawai'i. 186 pages + appendices.

[CEMML] Center for the Environmental Management of Military Lands, Colorado State University, Pōhakuloa Training Area Natural Resources Staff. 2017. Genetic Conservation and Outplanting Plan. United States Army Garrison, Pōhakuloa Training Area, Natural Resources Program, Hilo, Hawai'i, prepared for the U.S. Army Garrison, Hawai'i. 115 pp.

[CEMML] Center for the Environmental Management of Military Lands, Colorado State University, Pōhakuloa Training Area Natural Resources Staff. 2018. "Technical Report and Post-Disturbance Assessment July 2018 Wildland Fire Training Areas 18, 19, and 22 Pōhakuloa Training Area, Island of Hawai'i". United States Army Garrison, Pōhakuloa Training Area, Natural Resources Program, Hilo, Hawai'i, prepared for the U.S. Army Garrison, Hawai'i. 14 pages + appendices.

[CEMML] Center for the Environmental Management of Military Lands, Colorado State University, Pōhakuloa Training Area Natural Resources Staff. 2019. 2018 Annual Report for Pōhakuloa Training Area, Hawai'i Island, Hawai'i. Recovery Permit TE-40123A-2. United States Army Garrison, Pōhakuloa Training Area, Natural Resources Program, Hilo, Hawai'i, prepared for the U.S. Army Garrison, Hawai'i. 21 pages + appendices.

[CEMML] Center for the Environmental Management of Military Lands, Colorado State University, Pōhakuloa Training Area Natural Resources Staff. 2020. 2019 Annual Report for Pōhakuloa Training Area Hawai'i Island, Hawai'i. Recovery Permit TE-40123A-2. United States Army Garrison, Pōhakuloa Training Area, Natural Resources Program, Hilo, Hawai'i, prepared for the U.S. Army Garrison, Hawai'i. 52 pages + appendices.

Cuddihy, L.W. and C.P. Stone. 1990. Alteration of native Hawaiian vegetation: effects of humans, their activities and introductions. University of Hawaii, Honolulu. 138 pp.

D'Antonio, C.M. and P.M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics 23: 63–87.

Fleishman, E. 2019. Reaching zero, 20 years to eradicate non-native ungulates in conservation fences at Pōhakuloa Training Area Hawai'i. Presentation Abstract. Center for Environmental Management, Colorado State University.

Fortini, L., J. Price, J. Jacobi, A. Vorsino, J. Burgett, K. Brinck, F. Amidon, S. Miller, S. Gon III, G. Koob, and E. Paxton. 2013. A landscape-based assessment of climate change vulnerability for all native Hawaiian plants. Technical report HCSU-044, Hawai'i Cooperative Studies Unit, University of Hawai'i at Hilo, and USGS. 134 pp.

[HBMP] Hawai'i Biodiversity and Mapping Program. 2010. Database records for *Stenogyne angustifolia.* University of Hawai'i at Manoa, Honolulu, Hawai'i.

[HDOA] Hawaii Department of Agriculture. 2009. Plant guidelines for importation to Hawaii. 2 pp.

[HDLNR] Hawaii Department of Land and Natural Resources. 2015. Rules amending Title 13, Hawaii Administrative Rules, Chapter 13–123, entitled "Rules Regulating Game Mammal Hunting." 78 pp.

[HDLNR-DOFAW] Hawai'i Department of Land and Natural Resources-Division of Forestry and Wildlife. 2016. Outplanting at Pu'uwa'awa'a report to U.S. Fish and Wildlife Service. Honolulu, Hawai'i. Unpublished.

[HDLNR-DOFAW]. Hawai'i Department of Land and Natural Resources-Division of Forestry and Wildlife. 2018. Report on controlled propagation of listed and candidate species, as designed under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai'i.

[HDLNR-DOFAW]. Hawai'i Department of Land and Natural Resources-Division of Forestry and Wildlife. 2020a. Map of outplanting at Pu'uwa'awa'a to U.S. Fish and Wildlife Service. Honolulu, Hawai'i. Unpublished.

[HDLNR-DOFAW]. Hawai'i Department of Land and Natural Resources-Division of Forestry and Wildlife. 2020b. Email from DLNR-DOFAW staff Edith Adkins to PIFWO staff Lauren Weisenberger on populations managed by the state. Dated 22 Apr 2020.

[HPPRCC] Hawaii and Pacific Plants Recovery Coordinating Committee. 2011. Revised recovery objective guidelines. 8 pp.

[HAVO] Hawai‘i Volcanoes National Park. 2016. Report on controlled propagation of listed and candidate species, as designed under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i.

[HAVO] Hawai‘i Volcanoes National Park. 2019. 2019 Annual Report to the US Fish and Wildlife Service Threatened and Endangered Plants Hawai‘i Volcanoes National Park. Recovery Permit TE-018078-21. 26 pages.

Javar-Salas, C.M., R. Pe‘a, F. Amidon, M.K. Reeves, and S.E. Miller, 2020. Hawaiian Islands Dry Forest. Encyclopedia of the World’s Biomes, Elsevier, 2019.

Lindqvist, C., and V.A. Albert. 2002. Origin of the Hawaiian endemic mints within North American *Stachys* (Lamiaceae). American Journal of Botany 89 (10): 1709–1724.

Lowe, S., D.L. Ball, M.K. Reeves, F. Amidon, and S. E. Miller. 2020. Hawaii: Mesic forests. Editors: M.I. Goldstein and D.A. Della Sala, Encyclopedia of the World’s Biomes, Elsevier, 2020.

[NTBG] National Tropical Botanical Garden. 2019. Report on controlled propagation of listed and candidate species, as designed under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i.

Pe‘a, R., C.M. Javar-Salas, F. Amidon, M.K. Reeves, and S.E. Miller. 2020. Hawai‘i’s Dry Grasslands and Shrublands. Encyclopedia of the World’s Biomes, Elsevier, 2019.

Perkins, K.S., Stock, J.D., Nimmo, J.R. 2018. Vegetation influence on infiltration in Hawaiian soils. Ecohydrology, 11:e1970. https://doi.org/10.1002.eco.1973

Sato, H.H., Ikeda, W., Paeth, R., Smythe, R., and Takehiro, Jr., M. 1973. Soil survey of the island of Hawaii, State of Hawaii. U.S. Department of Agriculture, Soil Conservation Service, in Cooperation with the University of Hawaii Agricultural Experimental Station. 115 pp.

Shaw, R.B. and J.M. Castillo. 1997. Rare plants of Pōhakuloa Training Area, Hawai‘i. Center for EcologicalManagement of Military Lands, Fort Collins, Colorado. pp. 152.

Sherff, E.E. 1935. Revision of *Haplostachys*, *Phyllostegia*, and *Stenogyne*. Bernice Pauahi Bishop Museum Bulletin 136:1–101.

Smith, C.W. 1985. Impact of alien plants on Hawaii’s native biota. *In* Hawaii’s Terrestrial Ecosystems: Preservation and Management, C.P. Stone and J.M. Scott (eds.), Cooperative National Park Resources Studies Unit, University of Hawaii, Honolulu. Pp. 180–250.

[USFWS] U.S. Fish and Wildlife Service. 1979. Endangered and threatened wildlife and plants; determination that three Hawaiian plants are endangered species, State of Hawai‘i; final rule. Federal Register 44 (211): 62468–62470.

[USFWS] U.S. Fish and Wildlife Service. 1993. Draft recovery plan for *Haplostachys haplostachya* and *Stenogyne angustifolia*. U.S. Fish and Wildlife Service, Portland, Oregon. 55 pages.

[USFWS] U.S. Fish and Wildlife Service. 2012. 5-Year Review for *Stenogyne angustifolia*. U.S. Fish and Wildlife Service, Portland, Oregon. 24 pages.

[USFWS]. U.S. Fish and Wildlife Service. 2016. USFWS Species Status Assessment Framework. Version 3.4 dated August 2016.

[USFWS] U.S. Fish and Wildlife Service. 2020a. Recovery outline for Hawaiian multi-island species. U.S. Fish and Wildlife Service, Portland, Oregon. 36 pages.

[USFWS] 2020b. Unpublished GIS data. U.S. Fish and Wildlife Service, Pacific Islands Field Office, Honolulu, Hawai‘i.

Vitousek, P.M., C.M. D’Antonio, L.L. Loope, M. Rejmanek, and R. Westerbrooks. 1997. Introduced species: a significant component of human-caused global change. New Zealand Journal of Ecology 21: 1–16.

Volcano Rare Plant Facility. 2013. Report on controlled propagation of listed and candidate species, as designed under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i.

Volcano Rare Plant Facility. 2014. Report on controlled propagation of listed and candidate species, as designed under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i.

Volcano Rare Plant Facility. 2015. Report on controlled propagation of listed and candidate species, as designed under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i.

Volcano Rare Plant Facility. 2018. Report on controlled propagation of listed and candidate species, as designed under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i.

Volcano Rare Plant Facility. 2019. Report on controlled propagation of listed and candidate species, as designed under the U.S. Endangered Species Act. Unpublished report

submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i.

Wagner, W.L. and S.G. Weller. 1999. Rediscovery and assessment of *Stenogyne sherffii* Degener (Lamiaceae). Novon 9 (3): 448–449.

Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1999. Manual of the Flowering Plants of Hawaii. University of Hawaii Press and Bishop Museum Press, Honolulu.

Welch, A.J., K. Collins, A. Ratan, D.I. Drautz-Moses, S.C. Schuster, C. Lindqvist. 2016a. The quest to resolve recent radiations: plastid phylogenomics of extinct and endangered Hawaiian endemic mints (Lamiaceae). Molecular Phylogenetics and Evolution 99: 16–33.

Welch, A.J., K. Collins, A. Ratan, D.I. Drautz-Moses, S.C. Schuster, C. Lindqvist. 2016b. Data characterizing the chloroplast genomes of extinct and endangered Hawaiian endemic mints (Lamiaceae) and their close relatives. Data in Brief 7: 900–922.

Weller, S.G. and A.K. Sakai. 1990. Stenogyne. pp. 831–843 *In*: Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1999. Manual of the Flowering Plants of Hawaii. University of Hawai‘i Press and Bishop Museum Press, Honolulu.

Wood, K.R. and H. Oppenheimer. 2008. *Stenogyne kauaulaensis* (Lamiaceae, a new species from Maui, Hawaiian Islands. Novon 18: 544–549. doi: 10.3417/2008053.